using the new OVERFLOW-D interface in OVERGRID. Simple widgets allow the user to define the different bodies and to specify their attributes such as mass, moments of inertia, center of gravity, and applied loads.

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Multi-Level Parallel Computations of Unsteady Turbopump Flows

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The objective of this effort was to provide a computational framework for the design and analysis of the entire fuel supply system of a liquid rocket engine, including high-fidelity unsteady turbopump flow analysis. This capability is needed to support the design of pump subsystems for advanced space-transportation vehicles that are likely to involve liquid propulsion systems. To date, computational tools for the design and analysis of turbopump flows are based on relatively lower fidelity methods. An unsteady, three-dimensional viscous flow analysis tool involving stationary and rotational components for the entire turbopump assembly has not been available for real-world engineering applications. The present effort provides developers with information such as transient flow phenomena at start up, the effect of nonuniform inflows, system vibration, and the effect on the structure.

In order to compute the flow on grids with moving boundaries, the overset-grid scheme was incorporated with the flow solver such that new connectivity data are obtained at each time step. The overlapped-grid scheme allows subdomains to move relative to each other, and provides a general flexibility when the boundary movement creates large displacements. Figure 1 shows the model for boost pump and the steps taken in the simulation procedure.

A parallel version of incompressible Navier-Stokes solver (INS3D) was developed by using
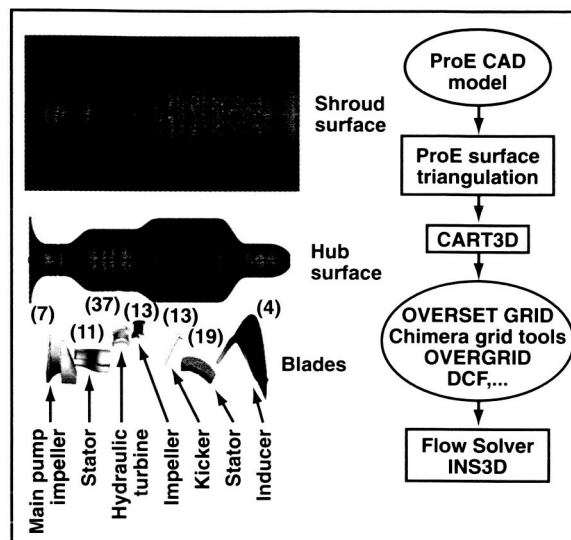

Fig. 1. Boost pump model and steps taken in the simulation procedure.

a Multi-Level Parallel (MLP) approach. This approach differs from the Message Passing Interface (MPI) approach in a fundamental way in that it does not use messaging at all. The coarsest level parallelism is supplied by spawning of independent processes via the standard UNIX fork. The boundary data for the overset-grid system is archived in the shared memory arena by each process. Other processes access the data from the arena as needed. Figure 2 shows INS3D-MLP performance versus computer processing unit (CPU) count for the 19.2 million-grid-point Space Shuttle Main Engine (SSME) impeller model.
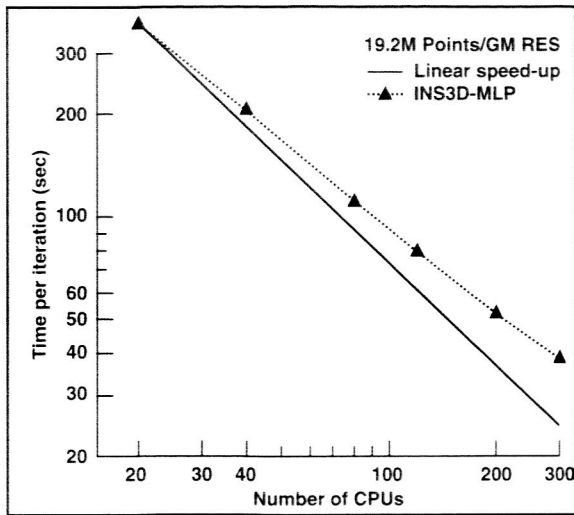
Fig. 2. INS3D-MLP performance versus CPU counts for Origin 2000.

The MLP version of code shows 73% of the linear speed-up performance. When MLP performance is compared with MPI performance, 19% more speed-up is observed by using the MLP version of the code. With pin-to-node implementation in the MLP version of the code, an additional 40% speed-up is obtained. The resulting code was applied to compute unsteady flow through the SSME turbopump, which contains 114 zones with 34.5 million grid points. Velocity magnitude contours during the pump start-up procedure is plotted in figure 3.

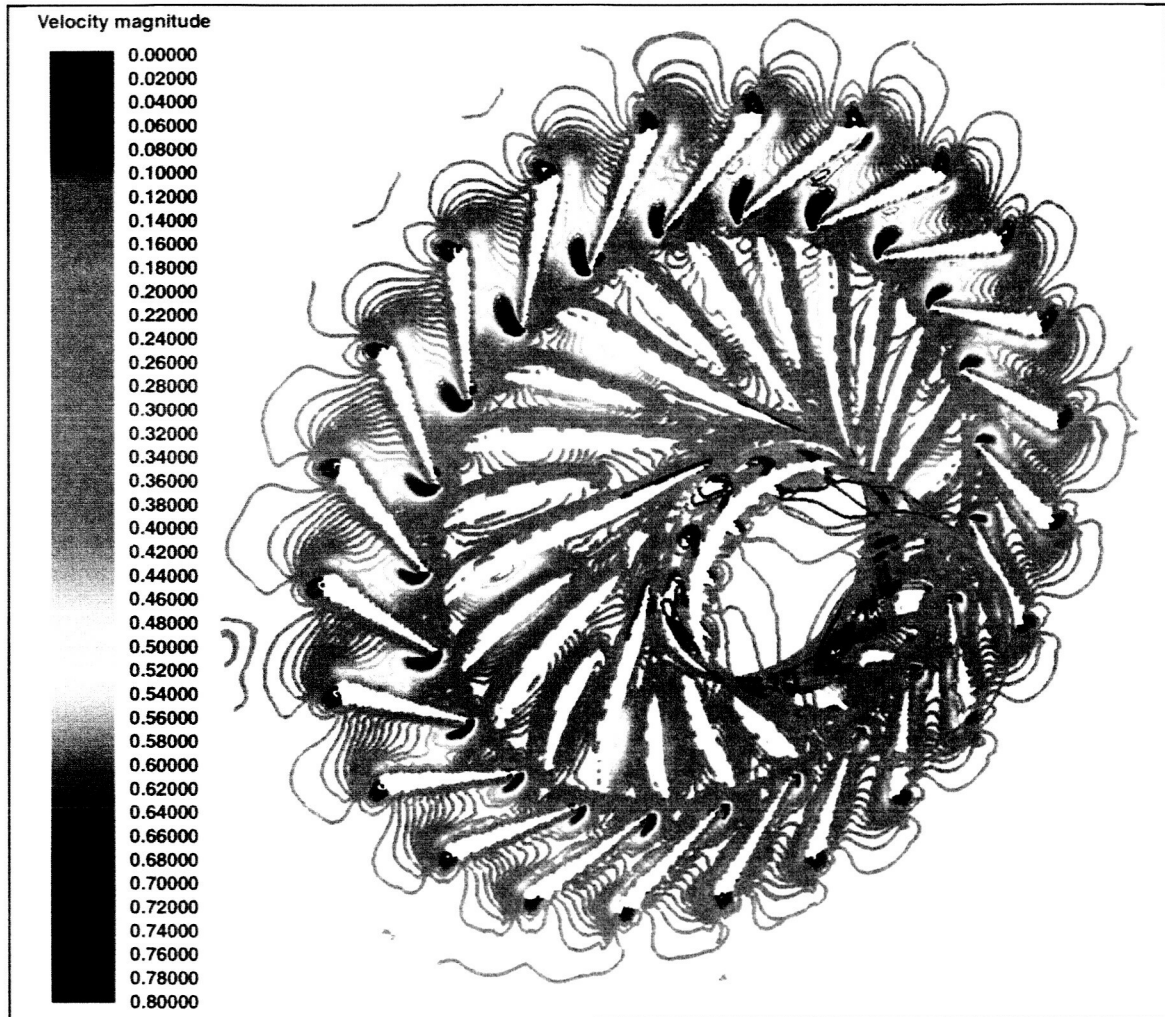Point of Contact: Cetin Kiris
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Fig. 3. Velocity magnitude contours during the pump start-up.